CARBON AND CARBON-COMPOUNDS

THE wayward and inconstant train of coloured light-bands that spectroscopists have noted and distinguished in the spectra of various carbon-compounds in flames and gas-vacuum tubes are as yet far from having all received their full and appropriate interpretations. The extent to which they abound as impurities in almost all spectral vacuum-tubes is a common observation, and in a survey of this kind, aiming at no systematic exploration, of a variety of end-on vacuum-tubes in the large and perfect spectroscope erected by Prof. Piazzi Smyth for the examination of auroræ, I have had from time to time, at his kind invitation, excellent opportunities for discriminating some of the component groups and clusters of the carbon-denoting series from each other pretty clearly.

Among the least alterable and changeful in its appearance of these coloured ranks is the five-tongued spectrum of wedge-like bands best seen in the end-on prismatic view of a coal-gas blow-pipe flame. Its bands have shaft-lines at the edge and on their fading slopes, with the exception of the last or violet one, just including within its bright edge the solar line of Fraunhofer's spectrum, G. This has a fine-line precursor, nearly coincident with Hγ, and a faint haze-band preceding it. Close to the place of b_1 in the solar spectrum appears the bright edge or chief shaft-line of the green band, fitly styled the "green giant," as it is the real Anak of the coal-gas flame-spectrum. Its less refrangible similitudes in the yellow-green and orange-red are quite subordinate groups, the latter being only discernible in spectroscopes of large aperture and of very great transparency. The fifth finger of this spectral gauntlet is a blue band, or quintett of five close lines pretty equally spaced and pretty equal in brightness, with little haze between them, lying once or twice its own breadth on the more refrangible side from Hβ (F.). The frontispiece of Watt's "Index of Spectra" contains a figure of this spectrum; and wave-length positions and symbols and descriptions of its groups are given in the body of the work, under the title "Carbon, Spectrum I." α, γ, δ, ϵ, f (β and η *carent*) are the five familiar potentates of the blow-pipe flame; but the two line-bands ζ, θ, one on each side of f, added in the figure and in the text of Watt's "carbon-spectrum I.," are not visible in the blow-pipe flame-spectrum. Along with a similar ultra-violet cluster just following H K in the solar spectrum, they form a triumvirate, the spectral origin of which Professors Liveing and Dewar have recently affirmed to be cyanogen. A reason to question the correctness, however, of Messrs. Liveing's and Dewar's surmise presented itself to me in my examination of the end-on tubes by the spectacle of the six-lined violet cluster θ rearing itself, without any accompaniment of its blue associate ζ, into extraordinary magnificence in a Marsh-gas tube. The grey or ultra-violet member of the trio was indeed weakly discernible at the same time; and in just this relative brightness and condition of extreme isolation from every other spectral feature I have recently observed these two violet and ultra-violet line-clusters in the blue flame part of the arc between particularly pure carbon poles in the Brush's or Anglo-American Company's electric light.

Another reason for suspecting multiplicity of form in the carbon-spectrum by itself occurred to me in an examination of the spectrum of cyanogen in an end-on tube. A perfect counterpart, it is well known, of the blow-pipe flame spectrum is producible by the induction-spark in vacuum-tubes of olefiant gas. Accompanying it however is another spectrum which in its fullest purity and intensity is equally well known to be produced by a weak induction-spark in tubes of carbonic oxide and carbonic acid gas. The blue quintett and the violet G-band are wanting in this spectrum. The edges of the green, citron and orange-red bands are displaced, and these bands are devoid of shaft-lines, being composed entirely of haze and fine linelets which smoothly shade them off. The olefiant gas and "carbonic oxide" spectra mingle together, usually in divers proportions in the carbon-impurities of gas-vacuum tubes.

Two cyanogen tubes (one of them of hardest glass) prepared by M. Salleron betrayed alike only the smallest trace of hydrogen by its red line, when they were lighted up by the induction-coil. Aqueous and atmospheric oxygen may therefore be presumed to have been pretty completely expurgated from these tubes, and the gas which charged them to have been an exceptionally pure compound of nitrogen and carbon. Far brighter, notwithstanding this, than in any other vacuum-tube, the smooth-shaded "carbon-oxide" bands made their appearance; and equally splendid with them was the close-ribbed red and yellow fluting forming the less-refrangible part of the spectrum, figured and described by Angstrom and Thalèn as that of "nitric oxide." The coincidence with the same spectrum of the bright cyanogen-tube lines in the blue and violet spectral regions was not closely examined; but as far surpassing in brightness the red-end view of it obtained in any other nitrogen-holding vacuum-tube (nitric oxide itself not excepted), the rasp-like ridges of the so-called nitric oxide spectrum were immediately measured with great care and accuracy. Angström's positions and *tableau* (exactly reproducing that of Plücker and Hittorf) of this region were completely verified; and the discussion of the well-based determinations left no doubt that while a simple order reigns sensibly among the small linelet features of each separate ridge, the ridges have no perceptible connection with each other or with the linelet-intervals upon them in the pitch of their wave-frequencies, although they follow each other closely in a gradually narrowing succession. In the rest of the nitrogen-spectrum, where the ridge-intervals are much wider, it is again not possible to trace between the ridges any simple wave-period connection.

Were I not from these measures, and from the foregoing considerations disposed to regard shaded spectral bands as independent systems of vibration, indicating most probably particular atomic groupings in a molecule, I should have beheld with some surprise the complete and thorough metamorphosis shown me by Mr. Lockyer since the above particulars were noted, which the smooth-banded "carbon-oxide" spectrum undergoes by introducing a condensing-jar, or better, a jar and air-break, into the circuit of the induction-coil. The smooth shadings disappear, the shaft-lines, the "Anak and the sons of Anak" of the olefiant-gas or blowpipe-flame spectrum make their appearance in their place; even the blue quintett of that spectrum comes forth from its hiding-place; and, as far as I could examine the spectral appearance of the carbonic-oxide tube in the now condensed discharge with complete precision, the whole blow-pipe flame, or so-called "hydro-carbon" spectrum, is perfectly reproduced. If we cannot admit, as I think that the cyanogen-tube experiment forbids us to do, that a chemical transformation has taken place, then we must acknowledge that among the forms which the spectrum of carbon is capable of assuming, there may, by subdivision of its molecule into separate vibrating systems, exist not one, but as many different "low-temperature" spectra of that Briareus-like, hundred-fisted, or Proteus-like, hundred-visaged element, as the electric discharge is capable of dividing its evidently complex gaseous molecule into separate spectroscopically individual groups. A. S. HERSCHEL

PHYSICS WITHOUT APPARATUS

I.

IT is almost a proverb in science that some of the greatest discoveries have been made by the most simple means. It is equally true that almost all the

more important facts and laws of the physical sciences can be illustrated and explained by the help of experiments made without special or expensive apparatus, and requiring only the familiar objects of common life for their performance. The greatest exponents of popular science—and amongst them notably Faraday—delighted in impromptu devices of this kind. It is indeed surprising how throughout the whole range of natural philosophy the hand of the master can turn to account the very simplest and rudest of apparatus. A silver spoon, a pair of spectacle lenses, a tumbler of water, and a few sheets of paper suffice to illustrate half the laws of geometrical optics. A few pieces of sealing-wax, some flannel, silk, writing paper, pins, and glass tumblers will carry the clever experimenter a long way into the phenomena of electricity. These are things which any person can procure, and which any person can be taught to use. But their right use depends on the possession of accurate scientific knowledge and a clear understanding of *what* the various experiments are to prove. In fact the art of experiment and the science of inductive reasoning are the essential qualifications necessary to make *Physics without apparatus* profitable.

The short series of papers which it is now proposed to publish in NATURE under the title of *Physics without apparatus* will deal with some of the more important and interesting of these simple matters of experiment. The subject of them has been more immediately suggested by the publication in our contemporary, *La Nature*, of a kindred series of articles by Mons. G. Tissandier, from which a number of the illustrations we present to our readers are taken. The matter of the present series is however new.

Amongst the simple mechanical laws with which a beginner in physics must acquaint himself is that commonly referred to as the *law of inertia*, which is, however,

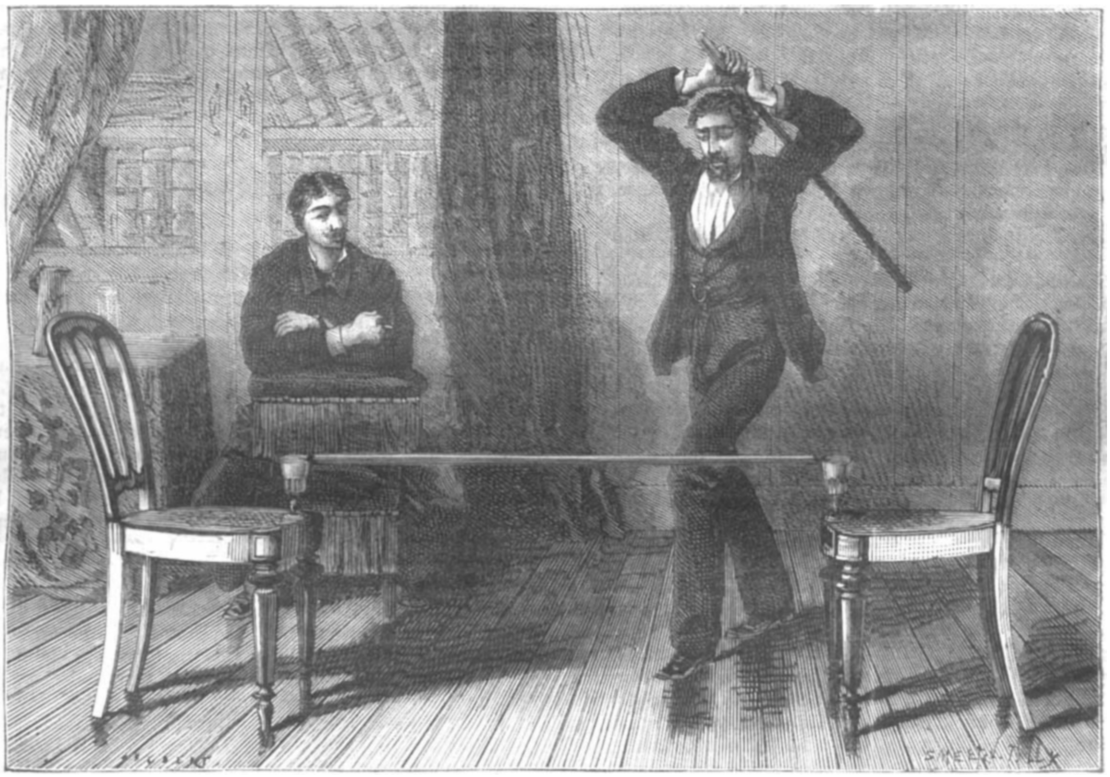

FIG. 1.

very often so imperfectly expressed as to be misapprehended. It requires force to move matter, not because matter is inherently lazy or sluggish, but because it possesses *mass*. The greater the mass of matter in a ball, the harder work is it to send it rolling. Force is also required to stop matter that is moving, the reason again being that a mass moving under the impulse of an impressed force possesses a certain moving energy which cannot be at once reduced to nothing. In either case—either to move a mass or to alter the motion of a mass—force must be employed and energy expended. Of this law of inertia many examples might be given: and there are many curious facts which this law serves to explain. Some of the most striking of these are those in which the effect of sudden forces is different from that which might have been expected. In Fig. 1 we give an illustration of an experiment of this nature. A wooden rod—say a broomstick—has a couple of needles fixed into its ends, and it is then supported upon two wine-glasses resting upon two chairs. If a heavy poker is now brought down very violently upon the middle of the stick it will break in two without the needles or the glasses being broken. A feeble or indecisive blow will fail to do this, and will break the glasses or the needles, or both. Here the moving energy of the heavy mass, the poker, is suddenly transferred to the middle of the stick, so suddenly that it is broken asunder before the thrust has *time* to reach the fragile supports.

Another simple experiment on inertia is equally instructive. Lay any ordinary visiting-card upon the knuckle, or upon the top of an inkstand or other convenient support. On the card place a brass weight, or a spool of thread, or any other small heavy object. Now flip away the card with the finger and thumb; it will fly out, leaving the heavy object where it was. In the same way if a dozen draughtmen are piled up one upon another

in a column, the lowest one can be removed without making those above it fall, by hitting it aside with a very rapid stroke with a table-knife. Here again a feeble stroke will fail.

Our second figure illustrates inertia in another way. A heavy metal ball is hung by a thread to the ceiling or to a shelf, and another thread is attached below. Tug at the lower thread, and it will break. If the tug be slow the ball will come down too; but if the tug be sharp and fierce

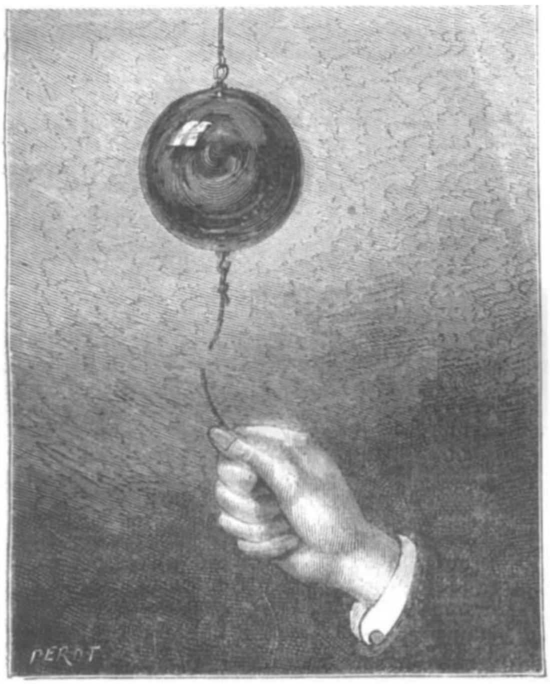

FIG. 2.

the thread will break off *below* the ball, breaking, in fact, before the pull has time to impart to the mass of the heavy ball a sufficient moving energy to enable it to rupture the string by which it hangs.

Many other illustrations of a similar kind might be narrated. Of these probably the most telling is that of firing a tallow candle from a gun through a deal board, in which it leaves merely a hole, as the writer can testify from several repetitions. Here, however, we are passing into the region of "apparatus," and must not pursue the matter further.

COUNT POURTALES

"IN the death of Louis François de Pourtales science has met a heavy loss. He was the Swiss representative of an old family, which had branches also in France, Prussia, and Bohemia. Trained as an engineer, he emigrated in early manhood to the United States at nearly the same time as the late Prof. Agassiz, to whom he was much attached, and whose pupil and fellow-worker he was. He entered the Government service in the department of the Coast Survey, and continued in it many years. His talents and industry made him a man of mark, to whom was intrusted much work that required original thought. Especially did he show interest in the problems of deep-sea soundings and the structure of the ocean bottom, an interest that led to profound observations on the physical geography of the Carribean Sea and the Gulf Stream. His papers on this subject were of the first order, and established his reputation in Europe as well as in America.

"By the death of his father he succeeded to the title, and received a fortune which enabled him to devote himself wholly to his favourite studies, and to do much in continuing the great work of Louis Agassiz. Appointed keeper of the Museum of Comparative Zoology, he gave himself, with untiring devotion, to carrying out the arrangement so laboriously planned by his friend and master. Dividing the task with the curator, Alexander Agassiz, he pushed forward his part of the work with the easy power of a strong and highly-trained intellect. Every day and all day at his post—now pursuing special investigations, and now directing the details of the museum—he was the model of an administrative officer.

"He had not an enemy, and could not have had one; for, although firm and persevering in temper, he possessed the gentleness of a child and a woman's kindness. His modesty amounted almost to a fault; and people wondered why a man who was master of three languages should talk so little. But with intimate friends he would speak freely, and never without giving information and amusement. His range of learning was very wide, and his command of it perfect; nor was it confined to mathematics, physics, and zoology. He did not scorn novels and light poetry, and was knowing in family anecdotes and local history. Indeed, it was a saying in the Museum that if Count Pourtales did not know a thing it was useless to ask any one else.

"His strong frame and temperate mode of life gave hope of a long period of usefulness, for he was only fifty-seven, and in the prime of his powers. But it was not to be. Stricken, without apparent cause, by an obscure internal disease, he succumbed, after some weeks of suffering heroically endured. In seven short years he has followed Louis Agassiz, and there seems no hand to take up his burden."

The above account of Count Pourtales appears in the *Boston Daily Advertiser* of April 20, and is, we believe, from the pen of Prof. Theodore Lyman. We would here, in addition, refer briefly to some of Count Pourtales' scientific work. Almost from the commencement of his connection with the United States Coast Survey he deeply interested himself in deep-sea questions, and some of the earliest observations on the nature of the deep sea bottom and of Globigerina mud were made by him. He wrote on the structure of Globigerina and Orbulina, and described the occurrence of the small Globigerina-like shells bearing spines in the interior of certain Orbulinæ, which he concluded were the swollen terminal chambers of Globigerinæ containing young in progress of development. The first step in deep-sea investigation in the United States was taken by the late Prof. H. D. Bache on his assuming the duties of the United States Coast Survey in 1844, when he ordered the preservation of specimens brought up by the lead. Every specimen was carefully preserved and labelled, and deposited in the Coast Survey Office in Washington. The microscopical examination of the specimens was commenced by the late Prof. J. W. Bailey, and after his death this work passed into the hands of Pourtales, who devoted his time to it in the intervals of other duties. That most important deposit, Globigerina mud, was first discovered by Lieutenants Craven and Maffit, U.S.N., during Gulf Stream explorations in 1853. In 1867 systematic dredging in deep and shallow water was commenced on the assumption of the superintendence of the Survey by Prof. B. Pierce, who ordered the dredging. At the suggestion of Louis Agassiz, dredgings were made down to a depth of 1,000 fathoms. In Prof. Agassiz' report one of the richest grounds for deep-sea corals, lying off Cape Florida, was named Pourtales Plateau. In 1871 Pourtales published what is probably his best-known work, namely, his "Deep-Sea Corals" ("Ill. Cat. Mus.